Transportation Research Part D 86 (2020) 102422

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

Do people who buy e-bikes cycle more?

Aslak Fyhri*, Hanne Beate Sundfør

Institute of Transport Economics, Gaustadalleén 21, 0349 Oslo, Norway

ARTICLE INFO

Keywords:
E-bike
Travel behaviour
Survey: mode share

ABSTRACT

Previous research shows that e-bike owners use private cars less than other transport user groups, and also report to have changed from motorised to non-motorised transport. A challenge with many studies is that they are either retrospective or cross-sectional, thus giving little control over confounding factors.

We followed up a short term trial where quite large mode change had been observed among participants. In the present study we conducted a before after-study with a customer group who bought an e-bike (N = 39) and a comparison group wanting to buy one (N = 142) using a survey with a travel diary to capture changes in travel behaviour. We also used a broader comparison group (N = 767) to test the robustness of the results from a policy perspective. The measurement period lasted up to six months.

We found that people who purchased an e-bike increased their bicycle use from 2.1 to 9.2 km per day on average, representing a change in bike as share of all transport from 17 to 49 percent. The comparison group had negligible changes in cycling during the same time period, and the choice of comparison group had a very marginal effect on the results. The results show that the large change in cycling we previously found of a trial scheme with e-bikes is replicated with actual customers. The change in cycling share is somewhat larger than it was for the short-term users, showing that mode change from e-bikes is not just a novelty effect.

1. Background

The e-bike has a strong potential to shift people from motorised to active transport. A number of studies have looked at effect of e-bikes on amount of cycling, as well as the mode change effects. The current study aims at building upon this literature by investigating if people who purchase an e-bike have a similar increase in daily cycling as participants in a short-term trial, using a more scientifically valid research design than previous studies have applied.

In a large scale study analysing data from the Dutch Mobility Survey (Kroesen, 2017) showed that e-bike users cycled 3.0 km a day, compared to 2.6 km a day for conventional cyclists, and also travel less with car than conventional cyclists. Cairns, Behrendt, Raffo, Beaumont, and Kiefer (2017) reviewed studies on e-bikes' mode change effect and summarizes findings from six European studies, and found that a number of other studies show similar results. According to this review the proportion of car journeys being replaced by bike journeys ranged from 16 percent to 76 percent. A challenge with all of the studies included in that review is that they are either retrospective (i.e. people report previous travel behaviour after they have purchased an e-bike) or cross-sectional (comparison of e-bike users with non-users at one time-point), thus giving little control over confounding factors. E-bike users differ from the general population in baseline travel patterns (Sun, Feng, Kemperman, & Spahn, 2020), hence deducing differences from cross-sectional studies might be problematic.

* Corresponding author.
E-mail addresses: af@toi.no (A. Fyhri), hbs@toi.no (H. Beate Sundfør).

https://doi.org/10.1016/j.trd.2020.102422

A recent study (Sun et al., 2020) tackles some of these challenges by exploiting the panel data from the Dutch Mobility survey, thereby being able to create a prospective study design where travel patterns for people who have bought an e-bike between two data collections (N = 107) are explored. The results of this study confirms previous findings that e-bike users reduce their share of conventional cycling, increase their total amount of cycling and reduce their amount of car driving (Sun et al., 2020). A limitation of this study is that is has no comparison group to compare the e-bike users with (the trial group is compared with the general population at baseline but not after purchase). In a context where cycling shares are quite stable throughout the year, or where there are no general trends for a change in cycling activity this is not a major challenge. But even Dutch cycling levels have seasonal variations (Thomas, Jaarsma, & Tutert, 2013), which might influence the results.

In other countries, such as the Scandinavian there are even more accentuated seasonal variation in bicycle use. In Norway the cycle share in winter is in the range of 1 to 2 percent of all trips, and rises to 8 percent in summer (Hjorthol, Engebretsen, & Uteng, 2014). Previous studies on e-bikes have acknowledged this fact (Winslott Hiselius and Svensson, 2017; Wolf & Seebauer, 2014), but the chosen solution, asking people to retrospectively report their baseline travel patterns is not satisfactory (Behrens & Mistro, 2010).

In a previous study (Fyhri & Fearnley, 2015) we measured the effects of electric bicycles through an experiment where approx. 60 participants were allowed to borrow the e-bikes for two or four weeks. We used a before-after design with a comparison group. We found that the trial group doubled their bicycle share and also had a substantial increase in their total bicycle use. In their review of the literature Sun et al. (2020), raises the timely objection that the changes we observed could have been due to a “novelty” effect, that one is curious about the bike when it is new, and then loses interest. Drop out from physical activity and exercise programs is a well-known phenomenon (Dishman, 1991). In a randomised controlled trial were participants were using a conventional bike for three months and then an e-bike, results indicated that participants were more inclined to lose motivation to cycle in the conventional bike period than in the e-bike period (Bjørnarå et al., 2019). It is therefore important to investigate the effect of the electric bicycle over a longer time span, and with people who actually buy an e-bike, rather than participants in a trial, while at the same time maintaining control with seasonal effects.

To meet this need, we conducted a before after study with a comparison group using a survey with a travel diary to capture changes in travel behaviour.

We worked in cooperation with providers who let their potential customers be invited to respond to the survey via posters in selected sports stores via social media (Facebook, Twitter). Everyone who answered the survey participated in the drawing of a gift certificate of NOK 5000. The purpose was for them to respond before using the electric bicycle.

It should be noted that in Norway, e-bikes needs to follow the regulations made by EU. Hence all legal e-bikes are of the *pedelec*[1] type, meaning that the motor assistant is limited to 250 W, and that the motor stops assisting beyond 25 km/h (European Committee for Standardization, 2011).

Results concerning total cycling use and physical activity from this study have been presented in another publication (Sundfør & Fyhri, 2017). However, data on changes in travel mode share has not been presented. Since the data collection is conducted in the same fashion as was done in the previous paper concerning short term effect of borrowing an e-bike (Fyhri & Fearnley, 2015), it is possible to make a direct comparison of the results here with the previous data.

An important issue is the choice of comparison group. Since the change in cycling for the trial group is compared with the change of cycling for the comparison group, this choice will have implications for the internal validity of the results. In other words, the comparison group should be matched as closely as possible to the trial group in order to show how those who gain access to an e-bike would travel in an alternative reality were the e-bike had not existed. In the previous study we used participants’ response to the question about willingness to purchase an e-bike as inclusion criteria. Those who answered “yes, absolutely” or “yes, probably” (N = 160) were included in the comparison group. However, the choice of comparison group also has to take into consideration the policy perspective of the measure. The results regarding mode change will have policy implications. Support schemes for e-bikes exist in a number of countries and cities around the world, either in the form of direct fiscal subventions or as other forms of promotion. In this context it might therefore be of interest to see if effects of e-bikes are the same when comparing with a broader more representative sample of the population.

To summarize, the main research question of this study is: Do people who buy e-bikes cycle more than they would have done without it?

More specifically we want to investigate

1. if buying an e-bike is related to a larger change in *total cycling kilometres* than short term access
2. if buying an e-bike is related to a larger change in *cycle share* than short term access
3. if the study outcome is dependent upon the choice of comparison group

2. Method

The samples for the current study came from two sources. The first was a convenience sample of people interested in buying an e-bike. The second sample was recruited through the Falck National Register of Bicycle Owners.

The survey program was conducted in parallel for both groups of participants. In the period from May to July 2014 the first round of surveys (T0) was administered. Some weeks after a given participant responded to the survey at T0, they would receive a post-

[1] Speed-pedelecs (with a speed cap of 45 km/h) are also allowed, but sales of these has not taken off.

survey (T1). This survey was sent out in waves so as to a capture a range of potential ownership lengths and seasonal conditions. The first respondents answered to this questionnaire on June the 18th and the last response was on November the 2nd. There was no difference between the samples in average response date. Note that there was a certain overlap between the two survey times.

2.1. Customer sample

A total of 338 people responded to the T0 survey. Of the 130 who responded to the T1 survey, 41 people had bought an electric bicycle after answering the preliminary survey, and were included in the customer group. The remaining 89 were included in the comparison group (no electric bicycle).

2.2. Comparison group

The comparison group was recruited through the Falck National Register of Bicycle Owners (a voluntary register for reducing 'own risk' in insurance cases). Of the total sample of 9000 members, 1995 responded to the questionnaire at baseline (T0), giving a response rate of 22 percent. All these were sent the follow-up questionnaire (T1), and 765 responded. All respondents lived in the Oslo region.

Some (N = 4) of the respondents from this sample could be identified as electric bicycle customers (stating that they had purchased electric bicycles after responding to the preliminary survey), and were moved to the customer group. Everyone who responded to the surveys participated in the drawing of a gift certificate of NOK 5000.

2.3. The final sample

For the analyses, a total of 45 people from the customer survey and from the Falck bicycle register are in the customer group. The full comparison group (N = 767) consists of the respondents from the recruited comparison groups from the Falck bicycle register and respondents (not yet bought an electric bicycle) from the Customer Survey. The full control is denoted as "C1". To better match the comparison group to the customer group, we created an additional comparison group, by using the participants' response to the question about willingness to purchase an e-bike as inclusion criteria. Those who answered "yes, absolutely" or "yes, probably" (N = 142) were included in the comparison group 2 (termed "C2").

Table 1 shows the age and gender distribution of the different samples.

Mean age for C1 (46.2 years) is somewhat above the age of the customer group (44.2 years), and below C2 (47.5 years). There is a higher share of women in the customer group (58 percent) than in the comparison groups (C1: 34 percent, C2: 39 percent). Bike ownership in all samples is above 90%, which is comparable with the ownership rate of the general population in Norway (Vågane, Brechan, & Hjorthol, 2011).

At follow-up, 25 percent of the e-bike owners reported to have owned it for less than a week, 20 percent between one and four weeks, 28 percent between 4 and 8 weeks, and 28 percent more than 8 weeks.

2.4. Survey items

The respondents filled in a travel diary, that captures *travel mode share*. The diary started with an explanation of the procedure for how to define a trip, i.e. the trip had to be associated with a travel purpose. The first question was whether the participant had travelled outside the home yesterday (yes/no). Subsequent questions were about travel mode, trip purpose, distance and time spent in a matrix. Travel mode could be on foot, by bicycle, e-bike, moped/motorbike, public transport, private car. For trip purpose, 14 categories of travel were used, borrowed from the National Travel Survey (Vågane et al., 2011). Information on trip purpose was not utilised in the current paper. The matrix had a limit of 6 trips.

2.5. Analysis procedure

The data were analysed using SPSS Statistics 24. To analyse travel mode, all trips regardless of trip purpose, were considered as eligible. We then excluded all trips exceeding 50 km. Remaining trips were aggregated to kms per transport mode. To test if changes for each travel mode was different from T0 to T1, paired samples t-tests was conducted. To test if the differences in mode change between groups were significant, we subtracted kms travelled at T0 from kms travelled at T1, for each transport mode, to create delta

Table 1
Mean age and gender distribution in the samples.

	Customer group *purchased e-bike*	Comparison group 1 (C1) *general sample*	Comparison group 2 (C2) *interested in buying e-bike*
Mean age	44.2	46.2	47.5
Female, percent	58	34	39
Owns a conventional bike, percent	93	98	98
N	45	767	142

Table 2
Average kilometres travelled on each mode of transport and cycling share for customers (those who have purchased electric bicycles) and the comparison groups C1 and C2, at T0 and T1.

	Customer group		C1		C2	
	T0	T1	T0	T1	T0	T1
Car	5.1	4.6	9.0	7.6	9.9	9.6
PT	2.1	1.9	4.5	4.3	4.4	5.2
Walk	1.6	1.0	1.9	1.9	1.7	1.5
Bike	2.1	9.2	5.1	6.0	3.0	4.0
Total km	10.8	16.6	20.5	19.8	19.0	20.3
Bike share	0.17	0.49	0.26	0.28	0.20	0.24
N	39	39	750	750	142	142

scores. These were analysed using one-way between groups analyses of variance (ANOVA).

Since the sample sizes vary, as well as the variances, it is useful to also compare effect sizes. Effect sizes are given as Cohen's *d* and interpreted according to Cohen's (1988) conventions. To compare with the results from the previous study we use the same comparison group as the last time, i.e. all participants who had not bought an e-bike (C1 in the current study). Since the previous study had not calculated delta-scores, but used repeated measures ANOVA, we have to calculate effect sizes based on these. We used an online calculator developed by Lenhard and Lenhard (2016) and follow recommendations from Morris (2008) for how to deal with pre- /post test data with different sample sizes, and use the pooled pre-test standard deviation for weighting the differences of the pre-post-means, the d_{ppc2} (Carlson & Schmidt, 1999).

The cycling share is a proportional figure, which can imply that its variance is heterogeneous, i.e. not independent of its value. Thus, calculations of effect sizes can be problematic. Preliminary tests indicated that the delta-scores, which are the basis for the ANOVA test are not suffering from unequal variance, so these estimates can be interpreted as showing true effect sizes.

3. Results

Of the total sample of 954 participants, we hold useful travel diary data from 931 participants. Table 2 summarizes the responses to the travel diary, and shows average kilometres travelled on each mode of transport for the customer group (those who have purchased electric bicycles) and the comparison groups C1 and C2, at T0 and T1.

The customer group increased their bicycle use from 2.1 to 9.2 km on average. At the same time, they decreased their use of walking, public transport and car driving from T0 to T1. The total amount of travel for the customer group increased from 10.8 to 16.6 km. C1 did not substantially change their total km travelled. There was an increase in cycling from 5.1 to 6.0 kms, and a decrease in car use. C2 had a small increase in total kilometres travelled, and an increase in cycling from 3 to 4 kms.

The customer group had an increased bicycle share from 17 to 49 percent from T0 to T1. The comparison groups had a small increase as well, from 26 to 28 percent (C1) and from 20 to 24 percent (C2)

The share of cycling kilometres that were conducted on an e-bike increased from 0 at T0, to 76 percent at T1 for the customer group. For both comparison groups it remained at 8 percent at both time points.

Paired samples t-tests were conducted to determine if these changes were significant. For C1, there was significant increases in bicycle use ($t\ (749) = 2.017$, $p = 0.044$) and a decrease in car use ($t\ (749) = -2.028$, $p = 0.043$). For the customer group, there was a significant increase in bicycle use ($t\ (38) = 3.687$, $p < 0.001$) and bicycle share ($t\ (38) = 3.327$, $p = 0.002$). For C2, none of the changes were significant.

To further test if the differences between groups were significant, we subtracted kms travelled at T0 from kms travelled at T1, for each transport mode, to create delta scores. Only the delta scores for cycling kms and cycling shares was significantly different between the groups.

Table 3 summarizes the delta scores (mean and SD) for cycling activity for the customer group and the comparison groups.

The customer group's delta scores were considerably larger than both of the comparison groups. While their increase in cycling kilometres amounted to 7.1 kms, the comparison groups increased their cycling with 0.9 and 1.0 km respectively. The change in cycling share for the customer group was as high as 32 percent compared to 2 and 3 percent for the comparison groups.

One-way between groups analyses of variance was conducted to test if these differences were statistically significant. The

Table 3
Delta scores (mean and SD) for cycling activity for the customer group and comparison groups C1 and C2.

	Customer group (N = 39)		C1 (N = 749)		C2 (N = 142)	
	Mean	SD	Mean	SD	Mean	SD
Bike kms	7.1	12.03	0.9	12.26	1.0	7.32
Bike share	0.32	0.60	0.02	0.45	0.03	0.33

Table 4
Summary of ANOVA tests. Delta scores (mean) for cycling activity for the customer group and difference between Customer group and comparison groups C1/C2. Degrees of Freedom, F-value, level of significance (p) and effect size (Cohen's d).

		Delta, mean	dF	F	p	Effect size, Cohen's d
Bike kms	T	7.1				
	T-C1	6.2	786	9.49	< 0.001	0.68
	T-C2	6.1	179	15.644	< 0.001	0.8
Bike share	T	0.32				
	T-C1	0.3	786	15.696	< 0.001	0.72
	T-C2	0.29	179	15.729	< 0.001	0.7

independent variable was the Customer/Comparison group dummy variables, and the dependent variable was the change in cycling share from T0 to T1. Table 4 summarises the results of the ANOVA tests. It shows delta scores (mean) for cycling activity for the customer group and difference between Customer group and C1/C2, as well as Degrees of Freedom, F-value, level of significance (p) and effect size (Cohen's d).

All differences between delta scores for the customer group and the comparison groups were statistically significant ($p < 0.001$). The effect sizes were of the same magnitude, ranging from 0.7 to 0.8, which are large or close to large effect sizes according to conventions (Cohen, 1988). C1 had a slightly smaller increase in cycling kms from T0 to T1 (0.9 kms) compared to C2 (1.0 km). Thus, the effect size for the change in bike kilometres was also slightly lower for this comparison (Cohen's d = 0.68) than for the comparison against C2 (Cohen's d = 0.8).

3.1. Comparison with data from 2013

The study outcome measures in the control and test groups from the current study are summarized in Table 5. The table shows means (S.D) for the customer group and for comparison group C2 at T1 and T2. The difference in mean score between T1 and T0 for each group is calculated and the difference between these two differences is termed "E-bike effect" (i.e. Customer group (T1-T0) - Comparison group (T1-T0)). Effect sizes are calculated as d_{ppc2} (Morris, 2008).

The study outcome measures in the control and test groups from the previous study with a short term trial (from Fyhri & Fearnley, 2015) are summarized in Table 6. The table shows means (S.D) for the customer group and for comparison group C2 at T1 and T2. The difference in mean score between T1 and T0 for each group is calculated and the difference between these two differences is termed "E-bike effect" (i.e. Customer group (T1-T0) - Comparison group(T1-T0)). Effect sizes are calculated as d_{ppc2} (Morris, 2008).

In the current study the "E-bike effect", i.e. the change in cycled kms from before to after for the customer group was 6.1 kms (representing a cycling share of 28 percent) relative to the comparison group. In the previous study, we found an "e-bike effect" of 6.6 km (representing a cycling share of 20 percent).

The effect sizes for the change in cycling kms were quite comparable between the previous ($d_{ppc2} = 0.78$) and the current study ($d_{ppc2} = 0.82$). When comparing effects on cycling shares the current study had a larger ($d_{ppc2} = 0.78$) effect size than the previous ($d_{ppc2} = 0.56$).

4. Discussion – owning or borrowing an e-bike?

The aim of this study was to investigate if purchasing an e-bike is related to a larger change in cycling, either expressed as kilometres travelled or as a bike share, than short term access, and secondly to explore if the choice of comparison group influences the results.

We found that people who purchased an e-bike increased their bicycle use from 2.1 to 9.2 km on average. At the same time, they decreased their use of walking, public transport and car driving. Cycling as share of all kms travelled increased from 17 to 49 percent after they had acquired the e-bike. When comparing with prospective e-bike customers (comparison group C2) effect sizes were large. When using the full sample of Falck members as comparison group C1, similar results were obtained, albeit with a slightly lower effect size for the change in bike kilometres.

The choice of comparison group had a very marginal effect on the results. The comparison group with people who want and e-bike

Table 5
Study outcome measures in the control and test groups from ownership data (current study). Mean (SD) bike kms and bike share. "E-bike effect" = Customer group (T1-T0) - Comparison group (T1-T0). Effect size calculated as d_{ppc2} (Morris, 2008).

	Customer group		Comparison group		«E-bike effect»	Effect size, d_{ppc2}
	T0	T1	T0	T1		
Bike kms	2.1 (4.9)	9.2 (11.8)	3.0 (6.6)	4.0 (8.5)	6.1	0.82
Bike share	0.17 (0.32)	0.49 (0.46)	0.2 (0.37)	0.24 (0.39)	0.28	0.78
N	39	39	142	142		

Table 6
Study outcome measures in the control and test groups from short term e-bike trial (from Fyhri & Fearnley, 2015). Mean (SD) bike kms and bike share. “E-bike effect” = Customer group (T1-T0) - Comparison group (T1-T0). Effect size calculated as d_{ppc2} (Morris, 2008).

	Customer group		Comparison group		«E-bike effect»	Effect size, d_{ppc2}
	T0	T1	T0	T1		
Bike kms	4.8 (8.1)	10.3 (12.2)	4.1 (8.6)	3 (6.4)	6.6	0.78
Bike share	0.28 (0.38)	0.48 (0.46)	0.2 (0.35)	0.2 (0.36)	0.20	0.56
N	66	66	160	160		

(C1) differed from the general sample (C2) at baseline. C1 had a higher share of females and a lower bike share. However, their change in transport activity did not differ enough from T0 to T1 to have any substantial influence on the results. The fact that the observed results are the same when comparing with a broader more representative sample of the population could potentially have direct implications for calculations of the socio-economic benefits of supporting e-bikes. In theory, it should be able to compare e-bike purchasers with a comparison group without knowing about the comparison groups intentions to buy an e-bike, and obtain valid results. However, future studies should test and confirm this conjecture, before this kind of approach is put into practise.

The “E-bike effect”, i.e. the change in cycled kms from before to after for the customer group was 6.1 kms (representing a cycling share of 28 percent) relative to the comparison group. In our 2013 study, participants were given an e-bike to use for two weeks’ time. Here we found an “e-bike effect” of 6.6 km (20 percent cycling share). Taking the effect sizes into consideration, the huge change we found in cycling activity for short-term e-bike users is replicated with actual customers. If anything, the change in cycling share is somewhat larger than it was for the short -term users.

This difference between the two studies can partly be attributed to the fact that the participants who bought an e-bike had a longer time to get accustomed to it. Exploration of the data showed a tendency for amount of cycling with the electric bicycle to increase with time, but that it diminished somewhat towards the end of the study period, most likely due to it becoming late in the cycling season (autumn). Due to a small sample size, and a low statistical power, we have not included these results. Nevertheless, the evidence from our data works against a novelty effect (Sun et al., 2020) for short term users. Rather, it confirms previous findings indicating that people tend to go through a learning process where they discover new trip purposes for where to use the e-bike (Dill & Rose, 2012). In this respect, it should be noted that also our previous study had included trial length as a variable in the analysis and showed that this played a significant role (higher mode share with a longer intervention) in determining the influence of the e-bike (Fyhri & Fearnley, 2015).

Previous studies, using cross sectional or retrospective designs have found mode change effects from e-bikes ranging all the way from 16 to 76 percent (Cairns et al., 2017). In the prospective study by Sun et al. (2020) the combined cycling level is not reported, but the authors state that it is “almost doubled” (Sun et al., 2020, p. 6). A visual inspection of figure 2 in their publication indicate a change from approximately 20–42 percent. In our previous study effect sizes were at the same level as this, whereas in the present study mode change is somewhat higher.

As noted, Norway follows the EU regulations regarding e-bikes. Whether results from a European context can be applied to a non-European country is an open question. Just as important as the regulatory differences between countries, are the differences in the bicycle’s potential role in the total transport system. In a context where the bicycle mainly has been seen as a recreational tool, it might be that e-bikes will lead to less mode change than what is observed here. That being said, also the Norwegian cycling culture has been domniated by recreational cycling for the last few decades (Fyhri, Bjørnskau, & Backer-Grøndahl, 2012). Hence, the context of Norway to a certain extent can be compared with that of the U.S, where the few studies that have hitherto been published indicate a mode shift from cars to cycling following from e-bike access (Fishman & Cherry, 2015). As the number of studies on mode share change from e-bikes now seem to be growing, future reseach should aim to investigate what context specific variables such as demographics and transport system characteristics influences the results.

As we have seen in this study, albeit with a quite small sample, e-bike ownership seems to lead to lasting changes. Future studies should investigate whether similar results are obtained when e-bike purchase is *subsidized*. Ideally this should be performed as a randomized controlled trial among people interested in purchasing an e-bike.

4.1. Strengths and limitations

A strength of the current study is that it is a prospective repeated measures design with test and comparison groups. Hence, we can avoid that our results are hampered by seasonal variations in cycling.

As most other travel behaviour studies we rely on self-reported measurements in the form of questionnaire items. It has been argued that surveys lead to under-reporting of walking and cycling, and the reported distances (kilometres and time) are not precise (Handy, Van Wee, & Kroesen, 2014). Future studies should aim to include more objective measures for comparison and for validating self-report measures.

The study was performed in Oslo, Norway where the cycling shares are low, compared to other European countries. Demographics and travel patterns differ between countries. We have previously argued that our results must be interpreted in light of this, and that it is not certain whether these results can be replicated in countries with hight cyling shares or where the e-bike already has gained a strong market position. We maintain this cautious remark. Still, our comparison with Dutch data indicate suprisingly similar results. Hence it seems that even in a context where the baseline cycling level is as high as in the Netherlands it is possible to acquire remarkably large changes from e-bike owneship in cycling activity.

Even if most of the data collection procedure was similar in our previous and present study, there was a slight difference in sampling strategy. In the previous study we used the membership base of a car-owner's association as a sampling base for both trial and comparison group. In the current study we used the Falck bike owner's registry. With approximately 250.000 members it covers approximately 5 percent of all households in Norway. It has a quite low membership fee (customers pay 30 Euros for 3 years upon bike purchase) and it covers a wide range of bicycle types, from the cheapest to the most expensive. Since the study is not intended to be representative of the whole population, but rather to look for *relative* differences in cycling shares slight differences in the baseline samples should not be critical for the results. In a previous analysis of the impact of using these different samples, we concluded that they were quite similar in relevant background characteristics, even if they both cycled somewhat more than the average population (Fyhri, Johansson, & Bjornskau, 2019).

One important limitation is the short study period. The full measurement program lasted for 6 months. The goal was to capture a range of different lengths of ownerships by natural variation. In practice the typical length of ownership was in the range of one to eight weeks. Only 28 percent had owned the e-bike for more than eight weeks. Our results indicate an increase of bike mode share with increased length of ownership, and retrospective studies have suggested the same (Winslott Hiselius and Svensson, 2017). To our knowledge, this is the first prospective study that measures e-bike use after more than just a few weeks of use. Still, future prospective studies should aim to confirm if the observed mode share changes are sustained for a prolonged period, and especially from one year to the next.

5. Conclusions

E-bikes are increasingly turning into an essential part of the urban transport system, and can be an important contribution to reducing environmental impact from transport by shifting people away from motorized transport. Our results confirm previous studies, but provides more controlled data about mode change from e-bikes than previously has been shown. People who buy an e-bike have more than a twofold increase in their use of bicycle for daily travel. An important implication from our analysis is that we show that studies that do not include a comparison group run the risk of over- or under-estimating the influence of an e-bike, depending on time of year. We find that the increased cycling is not just a novelty effect, but appears to be more lasting. Our study thus indicates that policy makers can expect a positive return of policy measures aimed at increasing the uptake of e-bikes, such as subvention schemes etc.

References

Behrens, R., Mistro, R.D., 2010. Shocking Habits: Methodological Issues in Analyzing Changing Personal Travel Behavior Over Time. International Journal of Sustainable Transportation, 4(5), 253-271. doi:10.1080/15568310903145170.

Bjørnarå, H. B., Berntsen, S., te Velde, S. J., Fyhri, A., Deforche, B., Andersen, L. B., & Bere, E. (2019). From cars to bikes–The effect of an intervention providing access to different bike types: A randomized controlled trial. Plos One, 14(7).

Cairns, S., Behrendt, F., Raffo, D., Beaumont, C., & Kiefer, C. (2017). Electrically-assisted bikes: Potential impacts on travel behaviour. Transportation research part A: policy and practice, 103, 327-342.

Carlson, K. D., & Schmidt, F. L. (1999). Impact of experimental design on effect size: Findings from the research literature on training. Journal of applied psychology, 84(6), 851-862. doi:10.1037/0021-9010.84.6.851.

Cohen, J. (1988). Statistical power analysis for the behavioral science. Hillsdale N.J: Erlbaum.

Dill, J., Rose, G., 2012. Electric bikes and transportation policy insights from early adopters. Transp. Res. Rec. 2314 1-6. Doi 10.3141/2314-01.

Dishman, R. K. (1991). Increasing and maintaining exercise and physical activity. Behavior Therapy, 22(3), 345–378. doi: https://doi.org/10.1016/S0005-7894(05)80371-5.

European Committee for Standardization. (2011). Cycles - Electrically power assisted cycles - EPAC Bicycles. . Retrieved from https://standards.cen.eu/dyn/www/f?p = 204:110:0::::FSP_PROJECT,FSP_ORG_ID:37542,6314&cs = 11DCF234E608CBEEA798ED6BD89F9CCE5.

Fishman, E., & Cherry, C. (2015). E-bikes in the Mainstream: Reviewing a Decade of Research. Transport Reviews.

Fyhri, A., Bjørnskau, T., & Backer-Grøndahl, A. (2012). Bicycle helmets–A case of risk compensation? Transportation Research Part F: Traffic Psychology and Behaviour, 15(5), 612-624.

Fyhri, Aslak, Fearnley, Nils, 2015. Effects of e-bikes on bicycle use and mode share. Transport. Res. Part D: Transp. Environ. 36, 45–52.

Fyhri, A., Johansson, O., Bjørnskau, T., 2019. Gender differences in accident risk with e-bikes—survey data from Norway. Accid. Anal. Prev. 132, 105248. https://doi.org/10.1016/j.aap.2019.07.024.

Handy, Susan, van Wee, Bert, Kroesen, Maarten, 2014. Promoting cycling for transport: research needs and challenges. Transp. Rev. 34 (1), 4–24.

Winslott Hiselius, Lena, Svensson, Åse, 2017. E-bike use in Sweden – CO2 effects due to modal change and municipal promotion strategies. J. Cleaner Prod. 141, 818–824.

Hjorthol, R., Engebretsen, Ø., & Uteng, T. P. (2014). Den nasjonale reisevaneundersøkelsen 2013/14 - nøkkelrapport. Oslo: Transportøkonomisk institutt.

Kroesen, M., 2017. To what extent do e-bikes substitute travel by other modes? Evidence from the Netherlands. Transport. Res. Part D: Transp. Environ., 53, 377–387. doi: https://doi.org/10.1016/j.trd.2017.04.036.

Lenhard, W., Lenhard, A., 2016. Calculation of Effect Sizes. Retrieved from https://www.psychometrica.de/effect_size.html.

Morris, S.B., 2008. Estimating Effect Sizes From Pretest-Posttest-Control Group Designs. Org. Res. Methods 11(2).364-386. doi: 10.1177/1094428106291059.

Sun, Q., Feng, T., Kemperman, A., Spahn, A., 2020. Modal shift implications of e-bike use in the Netherlands: Moving towards sustainability? Transport. Res. D: Transp. Environ. 78, 102202. doi: https://doi.org/10.1016/j.trd.2019.102202.

Sundfør, H.B., Fyhri, A., 2017. A push for public health: the effect of e-bikes on physical activity levels. Bmc Public Health 17 (1), 809. https://doi.org/10.1186/s12889-017-4817-3.

Thomas, T., Jaarsma, R., Tutert, B., 2013. Exploring temporal fluctuations of daily cycling demand on Dutch cycle paths: the influence of weather on cycling. Transportation, 40(1), 1-22. doi:10.1007/s11116-012-9398-5.

Vågane, L., Brechan, I., Hjorthol, R., 2011. National Travel Survey 2009 - key report (TØI report 1130/2011). Retrieved from Oslo: http://www.toi.no/getfile.php/Publikasjoner/T%D8I%20rapporter/2011/1130-2011/1130-2011-el.pdf.

Wolf, A., Seebauer, S., 2014. Technology adoption of electric bicycles: a survey among early adopters. Transport. Res. Part A – Pol. Practice, 69, 196–211. doi:10.1016/j.tra.2014.08.007.